Bull. Org. mond. Santé / *Bull. Wld Hlth Org.* 1972, **47**, 567-572

The effect of *Schistosoma mansoni* infection on the productivity of cane cutters on a sugar estate in Tanzania

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In an attempt to justify future snail control on an irrigated sugar estate in Tanzania, the effects of Schistosoma mansoni *infection on the productivity of apparently healthy cane cutters were investigated. The bonus earnings of cane cutters who were found to be infected with* S. mansoni *were compared, retrospectively, with earnings of uninfected cane cutters during the years 1968–69. For one 6-month period a more detailed study was made to correlate bonus earnings with actual output in tons of cane cut. It was found that in the four 6-month periods the mean bonus earnings of the uninfected cane cutters exceeded the mean bonus earnings of the infected men by 11.0 %, 11.4 %, 6.0 %, and 13.7 %, respectively. In all except the third period these differences were statistically significant. After treatment for* S. mansoni *infection, the workers were able to improve their earnings relative to both infected and uninfected workers. In a more detailed study of some of the workers during the third 6-month period, it was discovered that a 4 % difference in bonus earnings represented a 1 % difference in output. Taking into account the variations of bonus earnings it was estimated that the overall difference in productivity between infected and uninfected workers was 3–5 %.*

At Arusha Chini in northern Tanzania an integrated control programme against *Schistosoma mansoni* on an irrigated sugar estate resulted in a greatly reduced incidence (Fenwick, 1972) and a reduction in the prevalence and intensity of infection (Fenwick & Jorgensen, 1972). That experience made it possible to prescribe routine snail control procedures that can be expected to keep the level of *S. mansoni* on the estate at a low level in future years. However, there was insufficient evidence to justify expenditure for that purpose since the infection appeared to be relatively benign and there was little evidence of economic loss as a result of the disease.

In 1962–63, Foster (1967) showed on the same estate that body weight, physique, and haemoglobin values were unaffected by *S. mansoni* and he was unable to demonstrate that infected cane cutters on the estate did not work as hard in the fields as uninfected workers. He did show, however, that the rate of absenteeism was higher among infected workers, and that they presented themselves more frequently at the hospital for treatment.

Jackson (1956) and Sturrock (1965) expressed the opinion that the increase in the area of land under irrigation in developing countries would lead to an increase in schistosome infection. The former urged action, stating that " it has been my experience that a schistosomal infestation, if it is heavy enough, will reduce an individual to a point where death will be the final result unless measures are taken to eliminate the worms ". On the other hand Gordon (1953) was unable to obtain reliable evidence for or against any marked loss of manpower being attributable to *S. haematobium* and/or *S. mansoni* in the Sudan.

In a further attempt to find out to what extent cane cutters at Arusha Chini are affected by *S. mansoni* infection the present study was carried out by assessing the bonus earnings awarded to cutters during 1968 and 1969. In the 5 years since the study undertaken by Foster two important changes had occurred on the estate. Firstly, the labour force had become more static, since employment was by 1968 on a

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semipermanent basis. This meant that the workers and their families would, in the absence of control measures, be exposed to *S. mansoni* infection for long periods of time with the possibility that the situation feared by Jackson might arise. It also meant that the subjects of this study generally had long-standing infections rather than the more recent infections investigated by Foster.

The second change was that during 1968 and 1969 there was uninterrupted snail control on the estate, which led to a marked reduction in the transmission of the disease. This meant that it was possible to include in the study a relatively large group of uninfected workers as controls.

METHODS

The men employed as cane cutters were regularly screened and those who were obviously unhealthy and those who were poor workers were not retained. As differences in productivity were expected to be small it was necessary to include as many men as possible in the study and to do this the parameter selected for study was the total bonus earnings per man in each of the four 6-month periods in 1968 and 1969. This figure reflected the number of days the man had worked in that period and the output he had achieved on the working days.

A small study of the relation between the quantity of cane cut and the bonus rates was carried out to confirm that the relation between the two was the same as that estimated on theoretical grounds.

Bonuses were paid to men who cut more than a certain minimum amount of cane. Before cutting, the fields were classified by the manager into one of four groups, A, B, C, or D, according to weather conditions, cane type, extent of defoliation, etc. The minimum weight of cane to be cut per man before a bonus was payable was different for each group and so was the bonus rate.

The classification of cane cutters

The first step was to separate the men into " infected ", " uninfected ", or " treated " for each of the four 6-month periods. This was done after reviewing the details of each man's stool examinations and drug treatments. Any man who had not been examined at all during the 2 years was excluded from the whole of the study as his status was unknown. Likewise, any man who was first classified as uninfected and later classified as infected was excluded as his status was uncertain. Few were excluded on that basis.

Any man who was found to be infected at any time during the 1968–69 period, and who had no previous history of treatment (because he had not been examined), was deemed " infected " from the beginning of 1968 until such time as he was treated, and was classified as " treated " from that time onwards. He was, however, excluded from the study during the period of treatment.

Any man who was found uninfected during the 2 years with no recent history of treatment was deemed to have been " uninfected " at the start and to have remained so.

In classifying the men two assumptions were made: (1) that no self cures occurred and (2) that no new infections occurred during the 2 years.

On this estate there was no evidence for or against the occurrence of self cures because all patients found to be infected were treated immediately. However, the assumption that self cures did not occur was made because it allowed a larger number of men to be included in the study. Moreover, if the assumption was wrong the effect on the results would be to decrease any observed difference in output.

The second assumption was based on the evidence that, within the estate boundaries, transmission of the disease had been very greatly reduced if not arrested. New infections in cane cutters, whether from inside or outside the estate, were less than 10% in 1969 and 1970 as a result of the snail control measures instigated at the beginning of 1968. One result of assuming no transmission could be that a few men found infected in 1969, and classified as infected throughout, were in fact uninfected in 1968. This would apply to very few men, however, especially as some had already been excluded because of doubtful status.

The collection of data

The monthly bonus earnings for each man were summated to give the total earnings for each of the four 6-month periods, January–June 1968, July–December 1968, January–June 1969, and July–December 1969. The annual earnings for 1968 and 1969 were calculated for those men who worked throughout the study and who qualified for inclusion.

Any man who had been absent for 3 consecutive weeks or more in any one of the periods was excluded from the summary for that period, but otherwise no allowance was made for lost days, since with a large number of subjects over long periods it was expected that lost days, other than those attributable to schistosomiasis, would be fairly equal in each group.

The mean bonus earnings per man for each group were compared and the differences were tested for significance by means of the two-tailed " *t* " test. The effect of treatment for *S. mansoni* was examined by comparing the performance of a group of workers before and after treatment with the performance of infected men and uninfected men whose status did not change.

Because of the complicated bonus scales and the fact that the men worked in different fields, a second study was made to relate the bonuses earned to the quantity of cane cut and to observe whether any differences were due to lost working days or to higher productivity. This study was possible for only half of the cane cutters and for the first six months of 1969. The men were classified into " infected " and " uninfected " as before and the quantity of cane cut on each day of the 6-month period by each man was noted with an indication of the type of field worked (A, B, C, or D). From these figures the quantity cut in the 6-month period in each of the field types was calculated together with details of the number of working days in each type of field, the number of days with and without bonus, and the quantity of cane cut with and without bonus.

RESULTS

Bonus earnings

The results obtained in 1968 and 1969 for the three categories of workers are shown in Table 1.

The differences between the mean bonuses for the uninfected and infected workers were tested for significance and the P values are shown in Table 2. These data show that in each period, except the period January–June 1969, the uninfected men earned at least 11% more in bonuses than the infected men and that in each of these periods the difference was significant at the 95% confidence level.

For the January–June 1969 period, the difference in bonus earnings was only 6.0% and this difference was not significant at the 95% confidence level.

Effect of treatment on bonus earnings

The 198 infected workers whose bonus earnings were calculated for the period January–June 1968 were subdivided into two groups—those who were not treated and those who were treated between July and December 1968. The bonus earnings of these two groups before and after the treatment period are shown in Table 3 and are compared with the bonus earnings of the uninfected group.

The results show that the treated group improved their earnings relative to the untreated group. With respect to the uninfected men the treated group improved their earnings: before treatment they earned 12.2% less than the uninfected men and after treatment they earned 6.5% and 7.0% less.

Relation between bonus earnings and output

The selection of the period January–June 1969 for the detailed study of the relationship between bonus earnings and quantity of cane cut was unfortunate as this was the one period in which the difference in the total bonus earnings was not significant.

In this study (Table 4) the data for 63 uninfected men and 74 infected men were examined in detail. The infected men earned 3.97% less bonus than the

Table 1. Bonus earnings by infected, uninfected, and treated cane cutters during 1968 and 1969

Period	Infected cane cutters			Uninfected cane cutters			Treated cane cutters		
	No. in group	Total bonus earned (US $)	Mean bonus per man (US $)	No. in group	Total bonus earned (US $)	Mean bonus per man (US $)	No. in group	Total bonus earned (US $)	Mean bonus per man (US $)
1968									
Jan.–June	198	4 892	24.70	88	2 413	27.42			
July–Dec.	105	3 551	33.81	58	2 185	37.67			
All year	105	6 297	59.97	54	3 689	68.31			
1969									
Jan.–June	120	3 427	28.55	125	3 784	30.27	82	2 321	28.30
July–Dec.	43	1 474	34.28	95	3 703	38.98	73	2 646	36.25
All year	40	2 529	63.23	90	6 330	70.33	52	3 390	65.20

Table 2. Difference in earnings between infected and uninfected cane cutters

Period	Mean earnings (US $)			Percentage difference	P value
	Infected men	Uninfected men	Difference		
1968					
Jan.–June	24.70	27.42	2.72	11.0	0.025
July–Dec.	33.81	37.67	3.86	11.4	0.025
All year	59.97	68.31	8.34	13.9	<0.001
1969					
Jan.–June	28.55	30.27	1.72	6.0	0.085
July–Dec.	34.28	38.98	4.70	13.7	0.025
All year	63.23	70.33	7.10	11.2	0.035

Table 3. The effect of treatment for *S. mansoni* on the bonus earnings of cane cutters

Group or comparison	1968 Jan.–June	1969 Jan.–June	1969 July–Dec.
	Mean earnings per man (US $)		
uninfected group	27.42	30.27	38.98
treated group	24.08 (pretreatment)	28.30 (post-treatment)	36.24
infected (untreated) group	25.08	28.56	34.28
	Difference in earnings (US $) [a]		
uninfected/treated	3.34 (12.2 %)	1.97 (6.5 %)	2.74 (7.0 %)
infected/treated	1.00 (4.2 %)	0.26 (0.91 %)	−1.96 (−5.4 %)
uninfected/infected	2.34 (8.5 %)	1.71 (5.7 %)	4.70 (12.1 %)

[a] The figures in parentheses are the differences expressed as percentages.

Table 4. Mean performance and mean bonus earned by 74 infected and 63 uninfected cane cutters in the period January–June 1969

	Uninfected men	Infected men	Difference	Percentage difference
no. of days worked	96.17	95.78	0.39	0.41
% of days without bonus	12.26	13.49	1.23	10.03
quantity of cane cut (tons)	216.00	213.91	2.09	0.98
quantity of cane/day (tons)	2.246	2.233	0.013	0.58
bonus earned (US $)	31.95	30.73	1.22	3.97
no. of voluntary days worked	1.286	0.932	0.354	38.0

uninfected men while cutting 0.98% less cane, largely because they worked fewer days than the uninfected men (who volunteered for extra days on more occasions than the infected men) and cut less cane per day when they did work.

DISCUSSION

The aim of this study was to determine whether there was a significant difference in productivity between men infected with *S. mansoni* and uninfected men. The results of the bonus earnings survey clearly showed that, for 5 of the 6 calendar periods considered, uninfected men earned significantly more bonus than infected men. In the sixth period the difference in earnings of 6% was not significant. As the variable measured—bonus earnings—was related to productivity it follows that there was a significant difference in productivity between the two groups though the size of this difference is not known.

Other variables could have affected the result—e.g., absenteeism not related to schistosomiasis, differences in incentive, demographic differences—but these factors were not taken into account as it was considered that their effects would be similar in the relatively large groups examined. It should also be pointed out that this study was carried out on a selected group of men, all the obviously unhealthy individuals having been excluded, either at a pre-employment medical examination or during the study, if their output was unsatisfactory.

The study of the effect of drug treatment for schistosomiasis on productivity suggested that it resulted in an improvement in output. The earnings of the treated workers did not, however, equal those of the uninfected men: this was not to be expected since the study continued for only 1 year after treatment. In addition, it should be remembered that treated workers were classified as such if they received chemotherapy, and no account was taken of the success of the treatment; uncured workers perhaps accounted for 30% of the treated group.

The third aim of the study was to correlate bonus earnings with the quantity of cane cut, and it was shown that a 3.97% difference in earnings was obtained while the increase in cane cut was only 0.98%. If the ratio of 4 : 1 is extrapolated to the periods in Table 2, the differences in productivity become 2.75%, 2.85%, 3.5%, 1.5%, 3.4%, and 2.8%, respectively. This suggests that the difference in productivity between uninfected and infected men is in the region of 3%.

However, the particular period selected for this study was the one in which differences in the overall bonus earnings were not statistically significant, suggesting that in this period there were other factors in operation: there was, in fact, exceptional rainfall which made it difficult for all workers to earn any bonus at all. The differences in bonus earnings observed show that there was a significant difference in productivity of about 3% between uninfected and infected workers; however, it is considered that under better cane-cutting conditions the true difference might be about 5%. Thus the results demonstrate that *S. mansoni* infection does have a significant economic effect on this sugar estate, and that expenditure on schistosomiasis control on the estate is justified on economic grounds.

ACKNOWLEDGEMENTS

The authors express their thanks to the management of the Tanganyika Planting Company and to the Director of the East African Tropical Pesticides Research Institute for permission to carry out this study. Particular thanks are due to Dr T. A. Jorgensen for his help and encouragement and to Dr G. Webbe for reading the manuscript. The authors also thank the Secretary General of the East African Community for his permission to publish this paper.

RÉSUMÉ

INFLUENCE DE L'INFECTION PAR *SCHISTOSOMA MANSONI* SUR LA PRODUCTIVITÉ DES COUPEURS DE CANNES À SUCRE DANS UNE PLANTATION DE TANZANIE

En 1968/69, on a mené une enquête concernant les répercussions de la schistosomiase à *Schistosoma mansoni* sur la productivité des coupeurs de cannes dans une plantation de Tanzanie pourvue d'un système d'irrigation. On s'est basé pour cette étude rétrospective sur les primes payées aux coupeurs, infectés et non infectés, pendant quatre périodes consécutives de 6 mois.

L'analyse a montré que les primes octroyées aux travailleurs indemnes de schistosomiase étaient notablement plus fortes que celles reçues par leurs compagnons

infectés, la différence de gain étant statistiquement significative pour trois des quatre périodes considérées (11,0%, 11,4%, 6,0% et 13,7%). Le traitement des travailleurs infectés a eu pour résultat d'augmenter leurs gratifications.

Le premier semestre de 1969 a été choisi pour l'étude comparée des gains et du rendement de 63 travailleurs sains et de 74 travailleurs atteints de schistosomiase. Le montant des primes encaissées par les premiers était supérieur de 3,97%, leur production journalière de 0,58%, leur production globale pour le semestre de 0,98% et leur assiduité au travail de 0,41%. Ces données amènent à conclure que pendant la période de 2 ans la productivité des travailleurs sains a dépassé de 3-5% celle des coupeurs atteints de schistosomiase.

Bien qu'aucun des travailleurs infectés par *S. mansoni* n'ait été gravement malade, l'infériorité de leur productivité par rapport à celle des travailleurs sains montre l'importance économique de l'affection.

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